

Transport of organic carbon from the tropical volcanic
island of Dominica, Lesser Antilles

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Abstract

Small rivers on high-standing islands (HSIs) around the world provide a substantial contribution to the total amount of carbon delivered to the global ocean. Dominica is a volcanic island, with little organic carbon found in the bedrock, making it a highly suitable natural laboratory to investigate the delivery of organic carbon solely from soils. A study comparing total carbon fluxes from 11 rivers on Dominica investigates the dissolved organic carbon (DOC) and particulate organic carbon (POC) yields from different regions of the island to determine a possible relation between carbon transport and geographic and environmental characteristics of the rivers. Results show DOC and POC yields that range from 0.2 to 3.67 t km⁻² yr⁻¹, ranking among the highest carbon yields to date worldwide. Phosphate concentrations are low (< 5 ppb) to non-detectable, suggesting a phosphate-limited nutrient system affected by chemical weathering. A strong correlation of DOC values with watershed area and silicate weathering yields indicates the importance of volcanic active margin terrains to the annual global carbon cycle.

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Introduction

Small mountainous rivers in tropical regions experience high physical and chemical weathering rates caused by rapid uplift [*Carey et al.*, 2005a; *Lyons et al.*, 2005] and extreme rainfall events [*Goldsmith et al.*, 2008] and generally transport high concentrations of DOC and POC to the ocean [*Blair et al.*, 2003; *Burns et al.*, 2008; *Carey et al.*, 2005b]. Recently, there have been more studies focusing on organic carbon yields of major rivers around the world to determine a global budget for carbon transported to the ocean [e.g., *Ludwig et al.*, 1996; *Martin and Probst*, 1991; *Telang et al.*, 1991]. But for the most part global carbon budgets have neglected organic carbon input from small mountainous rivers (SMRs).

These river systems contribute a significant portion of the global sediment flux to the ocean [*Milliman and Syvitski*, 1992]. Some of the highest POC and DOC fluxes in the world also occur in SMR systems [*Burns et al.*, 2008; *Carey et al.*, 2005b; *Coynel et al.*, 2005; *Gomez et al.*, 2003; *Kao and Liu*, 1996; *Lyons et al.*, 2002]. With the high carbon fluxes and the high erosion rates necessary to produce large sediment loads, SMR systems also likely contribute substantially to carbon yields to the global oceans.

The organic carbon in small mountainous streams can originate from multiple sources. To distinguish between recently fixed carbon from vegetation and soil from ancient carbon derived from rock weathering is important to determine the net CO₂ drawdown for the present day global carbon budget [*Hilton et al.*, 2008]. Establishment of a global carbon export budget has been limited by a lack of data from tropical settings and no studies delineating the quantity and quality of the DOC and POC for the Caribbean have yet been conducted. Furthermore, there are few studies of other HSIs or volcanic islands and none of rivers near the small size of the Dominica rivers (watershed areas of 1–70 km²).

Site Description

The island of Dominica ($15^{\circ} 25' \text{ N}$, $61^{\circ} 20' \text{ W}$) is located in the center of the 850 km long Lesser Antilles volcanic chain, which lies along the eastern edge of the Caribbean plate boundary. Subduction of the North American tectonic plate beneath the Caribbean plate for 7 Ma has created a series of volcanic activity on Dominica that can be divided into four general age groups: Miocene, Pliocene, older Pleistocene, and younger Pleistocene (Figure 1). The northern portion of the island is covered primarily with Pelean domes whereas the southern portion of the island is dominated by more recent Plinian activity [*Lindsay et al.*, 2005]. Samples for DOC and POC were collected from streams draining predominantly andesite – dacite terrains of Pliocene and Pleistocene age (Table 1). Ignimbrite and tuff deposits associated with Pelean type volcanic activity within the last 100 k. y. are found across the island with outcrops in numerous river valleys including those of the Rosalie, Layou, and Geneva Rivers [*Roobal and Smith*, 2004].

The humid tropical climate of Dominica produces a high average rainfall of up to 10,000 mm yr⁻¹ with regional variations ranging from 1,000 mm yr⁻¹ on the west coast, 2,000 mm yr⁻¹ on the east coast, and up to 10,000 mm yr⁻¹ in the central mountainous areas [*Reading*, 1991]. The majority of this rainfall occurs during the tropical rainy season of May through December. Hurricanes pass over the island on average once every 15 years, usually towards the end of the rainy season, but Dominica is also affected by other extreme rainfall events associated with either smaller storms or hurricanes that pass nearby [*Neumann et al.*, 1978].

The topography of Dominica is rugged, with steep mountain slopes often in excess of 40°. This, coupled with the heavy rainfall that the island experiences, results in one of the highest river densities in the world [*Walsh*, 1985]. Heavy rainfall and steep topography also

produce high rates of both physical and chemical weathering [*Goldsmith et al.*, 2010]. Dominica experiences a high frequency of landslide events in the mountainous regions, especially during the rainy season [*Reading*, 1991]. Landslides most often occur after continuous high intensity rainfall events when soils saturation is most easily achieved [*Rouse et al.*, 1986].

More than 60% of Dominica is covered in tropical rainforest, concentrated in the center of the island. Much of the rest of the island is covered in secondary rainforest, which is younger growth and tends to be less dense than in the central mountainous area [*Reading*, 1991]. Dry scrub woodland covers the less densely populated western coast where the rain shadow produces a much drier climate [*Rouse et al.*, 1986]. Though the forests are primarily old growth, the size of many of the trees is relatively small, a possible result of recurrent damage from hurricanes. The majority of the population lives along the northeast and southern coastlines where land is cultivated for crops, primarily bananas [*Evans*, 1986].

Methods

Field Sampling Methods

Water samples were collected from streams throughout Dominica in July 2006, during the rainy season, and in March 2008, during the dry season. Sampling sites were generally near the mouths of rivers but away from tidal influence and any identified carbonate lithology [Roobal and Smith, 2004]. New, clean, low-density polyethylene (LDPE) bottles were used to collect water samples at field sites. Prior to collection, the bottles were soaked for a week in deionized (DI) water (18 M Ω), rinsed 5 times with DI water, and then rinsed three times with river water at the collection site. The sample pH was measured in the field, using a small separate aliquot of the sample water. Samples for POC analysis were collected from the top 1 cm of surface streambed sediment mud deposits (sand-sized grains and below) at each site on the flood banks, placed in 8 oz. polypropylene tubs, and stored in the dark until analysis.

There are limited stream gauge measurements of the Layou River recorded by the United States Geological Survey (USGS) in the 1980s and apart from these, no other gauging records were available for any of the sampled rivers. Instantaneous river discharge was measured manually at each field site during both the wet season in July 2006 and the dry season in March 2008. At each site a stream depth profile was determined and flows were measured at 20% and 80% of depth at a minimum of eleven stations across the channel [Goldsmith *et al.*, 2010]. The water flow was averaged to approximate mean discharge within each station which are summed to determine an instantaneous mean discharge. A previous statistical evaluation of the two-tenths and eight-tenths methodology conducted by Carter and Anderson [1963] showed multiple measurements obtained from sample locations with more than eleven measurement stations would yield a standard deviation of percentage errors of <5%.

Dissolved Organic Carbon Analysis

Samples were stored in the dark at room temperature immediately upon collection and shipped to The Ohio State University, Columbus, Ohio, where they were vacuum-filtered through MilliporeTM 0.7 μ m nominal pore size glass fiber filters directly into 20 ml amber glass vials. The filters, vials, and filter funnel to be used were combusted at 450° C before use for three hours and rinsed with 10% v/v HCl in DI water. Concentrated HCl was added to the filtered samples to acidify to pH 2 and samples were then stored at 4°C until analysis. DOC was determined by combustion at 650 °C and quantification of the CO₂ by non-specific IR adsorption using a Shimadzu 5050A Total Organic Carbon analyzer with high sensitivity catalysts [Carey *et al.*, 2005b]. Hydrocarbon-free air was sparged through the samples for 4 minutes to remove all purgeable organic and inorganic carbon. Remaining organic carbon was determined using 3–4 injections per sample. Relative standard deviation (RSD) of replicate analyses of the wet season samples ranged from 1.40% to 3.02%, whereas RSD of dry season samples ranged from 4.02% to 34.8%, with 9 of the 11 dry season samples below 12% RSD.

Annual discharge values were determined by extrapolating instantaneous wet and dry season discharge values into daily values and summing for the length of the season. The rainy season lasts for approximately eight months of the year (from May through December) and so was estimated to be 245 days long, whereas the dry season was estimated to be 120 days. DOC and POC yields were determined by multiplying the measured dissolved and particulate carbon concentrations in the stream water for each the wet and dry seasons by the seasonal discharge. The total seasonal yields were then summed to produce an annual yield for each river.

Particulate Organic Carbon and $\delta^{13}\text{C}$ Analysis

Streambed sediment samples were dried at 110 °C for a minimum of 96 hours and then sieved to separate into three grain sizes: coarse (>2.0mm), sand (2.0mm–63 μm), and fine (<63 μm) (Table 2). Percent organic carbon and carbon isotope analyses on the <63 μm portion were determined using a Costech Elemental Analyzer coupled to a Finnigan Delta IV Plus stable isotope ratio mass spectrometer under continuous flow using a CONFLO III interface. Approximately 10% of all samples were run in duplicate. $\delta^{13}\text{C}$ indicates the permil deviation of the ratio of $^{13}\text{C}:^{12}\text{C}$ relative to the Vienna Pee Dee Belmenite Limestone standard. Stable carbon measurements were made where the average standard deviations of repeated measurements of the USGS24 standards were 0.07 permil for $\delta^{13}\text{C}$.

Total suspended solids (TSS) were measured gravimetrically by filtering a known volume of re-suspended water sample, drying the filter at 125 °C overnight, and weighing the filter for total particle mass. Only dry season TSS samples were analyzed as wet season water samples were unavailable. However, sediment samples were available for both seasons and therefore the carbon concentration of the sediment was measured for both seasons. In POC yield calculations, the dry season TSS value was used for both the wet and dry seasons and was multiplied by the separate percent carbon in sediment values to get seasonal POC fluxes. This concentration was multiplied by the river discharge during each the dry season and the wet season and summed to produce an annual yield of POC to the ocean.

This methodology would likely result in a minimum POC yield, because higher rainfall and erosion during the wet season would likely result in higher levels of suspended sediment in the rivers and therefore higher than estimated carbon yields during the wet season. However,

even with the possibility of underestimating wet season POC concentration, the wet season organic carbon flux accounts for more than 80% of the estimated annual POC yield in each river.

Phosphate Analysis

Phosphate concentrations were measured in available samples on a Skalar Nutrient Analyzer using the phosphor molybdate blue method provided by the manufacturer. Measurements were reported as parts per billion (ppb) P as PO_4 and the approximate limit of detection of the instrument was 0.1 ppb P.

Results and Discussion

Dissolved Organic Carbon

For the eleven Dominica streams sampled, DOC concentrations ranged from 0.23 – 2.3 mg/L during the dry season and from 0.53 – 2.72 mg/L during the rainy season (Table 3).

Instantaneous discharge in each river at least doubled between the dry and wet seasons. The yield of a river is the total amount of DOC normalized to watershed areas that is transported to the ocean from one river during one year. The majority of the yearly DOC yield is generated during the rainy season, due to higher discharge and solute concentrations.

Annual DOC yields were 0.2–3.7 t km⁻² yr⁻¹ with the majority ranging 1.0–2.0 t km⁻² yr⁻¹ (Table 4). The highest value determined was for the Pagua River, with an annual DOC yield of 3.7 t km⁻² yr⁻¹. This high yield could be a result of agricultural activity that covers approximately 15% of the Pagua watershed [Reading, 1991]. The Mahaut River, which drains the smallest basin area, exhibited the lowest DOC yield of just 0.26 t km⁻² yr⁻¹.

The Dominica DOC yields are among the highest measurements around the world to date (Table 5). Many of the major world rivers have watershed areas up to five orders of magnitude larger than the rivers of Dominica and drain more developed and populated land [Ludwig *et al.*, 1996; Martin and Probst, 1991; Telang *et al.*, 1991]. Yet the DOC yields of Dominica rivers are comparable to those regions. Most of the previous work on organic carbon transport from SMRs focused on the small islands of Oceania, which are estimated to contribute as much as 35% of the total oceanic input of organic carbon [Lyons *et al.*, 2002]. DOC yields from New Zealand and Taiwan [Carey *et al.*, 2005b; Kao and Liu, 1996] are slightly higher than those from Dominica but are still within one order of magnitude. The other HSIs that have been studied, though still considered to be small watersheds, have basin areas that are 2 to 3 orders of magnitude larger

than the largest river sampled on Dominica (Table 5). There are also few data on carbon input into the ocean from volcanic terrain. Organic carbon yields in rivers of New Zealand, some of which drained volcanic bedrock, are in the same range as those of Dominica [Carey *et al.*, 2005b].

Particulate Organic Carbon

Estimated POC concentrations showed much less seasonal variation than DOC values. Dry season POC concentrations ranged 0.005–1.03 mg/L and wet season concentrations fell within a similar range of 0.005 – 1.13 mg/L (Table 3). There was no clear pattern of POC concentration being higher in one season than the other across a majority of the rivers.

Dominica POC yields ranged 0.002–1.66 t km⁻² yr⁻¹ (Table 4). The Pagua River also exhibited the highest annual POC yield (1.66 t km⁻² yr⁻¹). The Layou River exhibited the second highest POC yield (0.23 t km⁻² yr⁻¹) and drains the largest watershed area (Table 4) which includes a large range of topographic gradients and multiple vegetation types [Reading, 1991]. Given that stream gauging was conducted outside of the influence of any strong storm events, discharge values and calculated annual carbon yields presented herein likely represent conservative values.

The Dominica POC yields are close to some of the highest measurements from worldwide rivers. The highest of my measured yields are most comparable to POC values for the largest rivers around the world and to rivers draining other volcanic regions (Table 5). Small rivers draining volcanic regions of New Zealand have POC yields that are slightly higher but still within the range of the yields determined for Dominica rivers [Carey *et al.*, 2005b]. The few available POC yields for other HSIs are within one to two orders of magnitude larger than the

Dominica POC yields (Table 5). The DOC/TOC ratios for the Dominica rivers are all close to 1.0 and are consistently higher than DOC/TOC values for other world rivers.

Geographic Controls

Characteristics of the island and individual watersheds were analyzed to find controls of the DOC yields (Figure 3). There is a positive correlation between annual DOC yield and average basin rainfall ($R^2 = 0.38$, $p = 0.06$) (Figure 3a) and a negative correlation between DOC yield and stream gradient ($R^2 = 0.39$, $p = 0.04$) (Figure 3b) for Dominica rivers. Although these correlations may suggest a link between uplift rates or physical erosion rates with DOC fluxes, a lack of data for these two parameters in Dominica prevents any potential correlation at this time.

A plot of annual DOC yield versus watershed area (Figure 3c) shows a strong correlation in watersheds less than 30 km² ($R^2 = 0.61$, $p = 0.001$), though correlation decreases substantially when the Layou River (watershed area ~ 70 km²) is added to the data set. This relation emphasizes the contribution of the smallest class of watersheds to the global organic carbon yield. As a result of high river density and high DOC and POC yields, these heretofore overlooked carbon hot spots transport a significant mass of organic carbon to the global ocean.

DOC yields calculated as part of this study were compared with Dominica silicate weathering yields determined by Goldsmith et al. [2010]. There is a weak correlation between the two sets of data ($R^2 = 0.18$, $p = 0.19$) (Figure 3d). However, with the exception of the Pagua River the data all follow a general trend of increasing DOC yield with increasing Si weathering yield. The large DOC yield of the Pagua watershed could be a result of anthropogenic influence while the measured silicate weathering yield should be relatively unaffected by anthropogenic activity. A significant portion of the watershed is used for farming, which could contribute to the total carbon yields [Reading, 1991]. If the Pagua watershed is then omitted from this analysis, a

strong correlation ($R^2 = 0.77$, $p = 0.001$) between the annual DOC yield and the annual silicate weathering yield results. This correlation shows the connection between chemical weathering rates of bedrock and the physical erosion and runoff that produce high DOC yields.

Carbon Isotopes

Analysis of $\delta^{13}\text{C}$ was performed on the sediment samples from the wet and dry seasons of each river. The resulting data show no significant difference in $\delta^{13}\text{C}$ values between the two seasons. The average $\delta^{13}\text{C}$ value for the wet season samples is -26.86‰, whereas the average dry season $\delta^{13}\text{C}$ value is -26.52‰. The Pagua River, which is thought to be more heavily influenced by agriculture, shows more depleted $\delta^{13}\text{C}$ during both the wet (-27.82‰) and dry (-27.99‰) seasons compared to the average values for the remaining streams (-26.98‰ and -26.22‰, respectively) (Table 6).

Phosphate

Dissolved phosphate concentrations (Table 4) are generally low, below 4.5 ppb, with some below the limit of detection (0.01 ppb). The water samples taken during the dry season in 2008 exhibited slightly higher phosphate concentrations (2.1 ppb–3.5 ppb) than those taken during the wet season in 2006 (<0.1–3.2 ppb). Volcanic terrain is generally nutrient rich [Pringle and Triska, 1991] and geothermal activity can result in higher phosphate input into streams [Pringle *et al.*, 1993]. Only two of the Dominica rivers (Dublanc and Geneva) exhibit geothermal input greater than 1% [Goldsmith *et al.*, 2010]. Therefore, phosphate from geothermal activity is not likely to play a great role in the majority of these systems. The Pagua River exhibits the highest wet season phosphate concentration, which further suggests overland flow from agricultural land is affecting the chemistry in this system.

For streams draining the volcanic terrain of eastern Costa Rica, very little algal growth was observed in streams with low phosphate levels (7.9 – 23.7 ppb soluble reactive phosphorus) compared to the streams with higher phosphate levels, suggesting that a phosphate-limited system is less productive overall than a nitrate-limited system [Pringle *et al.*, 1993]. The majority of phosphate in a system is derived from the chemical weathering of parent rock and phosphate levels are shown to be highest during the sustaining phase of soil development when the most erosion and chemical weathering are occurring [Vitousek *et al.*, 1997]. In the case of Dominica, and other HSI, physical weathering limits the stage of soil development, thereby sustaining these high rates of chemical weathering [Carey *et al.*, 2005a; Goldsmith *et al.*, 2010; Lyons *et al.*, 2005]. My observed correlation of silicate weathering and DOC yields, coupled with low to non-detectable concentrations of dissolved phosphate, suggests chemical weathering rates may implicitly control primary productivity in these systems. Although these active margin locales recently garnered attention for their CO₂ consumption potential via chemical weathering [Carey *et al.*, 2005a; Goldsmith *et al.*, 2010; Lyons *et al.*, 2005], this new finding suggests they also play an important role as a biologic sink of CO₂.

Conclusions and Future Work

Organic carbon yields for small streams on the island of Dominica were measured and found to be similar to POC and DOC yields of major rivers of varying size and geographic areas around the world. Geographic controls of carbon transport within the river systems were considered and indicated a correlation between carbon yields with both rainfall and with silicate weathering yields. Phosphate measurements indicate a nutrient-limited system. $\delta^{13}\text{C}$ analyses show a possible indication of anthropogenic influence in individual rivers and little seasonal change overall. These controls help to define the characteristics of high organic carbon yielding rivers. The high DOC and POC yields of the Dominica rivers indicate the substantial contribution of small rivers on HSIs and add an important component to the small but growing global data set of carbon characterization and transport to the oceans.

Continued work on carbon yields of rivers similar to those on Dominica will continue to expand the available body of knowledge. The Dominica rivers are unique to the existing data set because of their small size and tropical volcanic terrain. The data from these river systems indicate significance of SMR carbon hot spots in global carbon transport to the ocean, but a larger and more diverse data set is needed to demonstrate the specific impacts of such systems. Although my data show overall trends within the system of Dominica rivers, more measurements of these rivers would provide a more complete understanding of carbon yields. With more carbon and discharge measurements spread out throughout the year and across the island, a better idea of the effects of geographic controls, rainfall events, and the link between carbon and silicate weathering yields could be obtained and the conclusions applied to similar systems worldwide.

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Table 1 - River basin characteristics

River Name	Sample Location	Average Basin Rainfall (mm yr ⁻¹)	Gradient	Major Vegetation (% land area)*	Age(s) of Primary Lithology [†]
Geneva (DS)	W 60° 18.620', N 14° 14.867'	4520	0.14	secondary rainforest (50%)	younger Pleistocene
La Ronde	W 61° 14.736', N 15° 19.263'	4557	0.19	montane (35%), secondary rainforest (35%)	younger Pleistocene
St. Joseph's	W 61° 25.283', N 15° 24.421'	2768	0.10	secondary rainforest (55%)	older Pleistocene
Bateli	W 61° 26.803', N 15° 27.253'	2768	0.11	dry scrub woodland (37%), tropical rainforest (33%)	younger Pleistocene
Hampstead	W 61° 21.782', N 15° 35.579'	3736	0.06	tropical rainforest (62%)	young to older Pleistocene
Rosalie	W 61° 15.384', N 15° 22.272'	6995	0.11	tropical rainforest (35%)	younger Pleistocene
Mahaut	W 61° 15.824', N 15° 21.29'	— [§]	0.14	secondary rainforest (80%)	Pliocene
Dublanc	W 61° 27.884', N 15° 30.935'	5310	0.10	secondary rainforest (33%), montane (32%)	Pliocene to older Pleistocene
Blenheim	W 61° 23.608', N 15° 35.475'	3272	0.04	secondary rainforest (65%), cultivated (35%)	Pliocene to older Pleistocene
Layou (DS)	W 61° 23.708', N 15° 24.772'	5933	0.03	tropical rainforest (37%), secondary rainforest (32%)	younger Pleistocene
Pagua (DS)	W 61° 16.601', N 15° 31.006'	4899	0.04	tropical rainforest (80%)	Pliocene

*[Reading, 1991]

[†][Roobal and Smith, 2004][§]data not available

Table 2 - Grain size distribution of river bed sediment

River	Sample Number	Fines, <63µm (g)	% Fines	Sand, 2.0-63µm (g)	% Sand	Gravel, >2.0mm (g)	% Gravel	Total (g)
Geneva (DS)	DO6-1	2.7352	1.3%	187.3027	89.8%	18.4585	8.9%	208.4964
Geneva (DS)	DO8-9	1.3435	0.6%	127.6219	59.5%	85.4250	39.8%	214.3904
La Ronde	DO6-5	1.8932	0.8%	212.9886	93.4%	13.0383	5.7%	227.9201
La Ronde	DO8-11	1.7835	0.8%	184.1471	82.2%	38.1125	17.0%	224.0431
St. Joseph's	DO6-9	2.4844	1.4%	166.0656	95.1%	6.0072	3.4%	174.5572
St. Joseph's	DO8-3	1.1886	0.8%	111.7073	79.4%	27.7588	19.7%	140.6547
Bateli	DO6-10	10.9914	6.7%	150.1230	91.6%	2.7343	1.7%	163.8487
Bateli	DO8-4	1.8684	1.0%	177.4815	98.3%	1.2582	0.7%	180.6081
Hampstead	DO8-15	2.5938	1.1%	225.6027	98.6%	0.6437	0.3%	228.8402
Rosalie	DO6-4	1.0760	0.6%	184.1296	95.2%	8.2628	4.3%	193.4684
Rosalie	DO8-13	2.3012	1.3%	154.8461	88.3%	18.2381	10.4%	175.3854
Mahaut	DO6-6	3.3035	2.5%	118.2067	90.7%	8.7954	6.7%	130.3056
Mahaut	DO8-12	7.2593	4.2%	121.6726	70.5%	43.6095	25.3%	172.5414
Dublanc	DO6-11	2.4521	1.0%	232.0586	95.8%	7.7457	3.2%	242.2564
Dublanc	DO8-5	0.9148	0.4%	211.2976	98.3%	2.7391	1.3%	214.9515
Blenheim	DO6-15	4.7416	2.3%	200.7052	95.9%	3.7309	1.8%	209.1777
Blenheim	DO8-14	0.7966	0.5%	164.1788	97.0%	4.3360	2.6%	169.3114
Layou (DS)	DO6-8	10.7912	4.9%	207.9800	94.2%	1.9525	0.9%	220.7237
Layou (DS)	DO8-2	0.1702	0.1%	170.8519	98.3%	2.7558	1.6%	173.7779
Pagua (DS)	DO6-29	1.6581	0.8%	165.7842	75.5%	52.1868	23.8%	219.6291
Pagua (DS)	DO8-17	5.3820	2.2%	220.4703	91.8%	14.2506	5.9%	240.1029

Table 3 - Seasonal sample data

Summer 2006 (wet season)						
River Name	Sample Number	Date Sampled	Instantaneous Wet Season Discharge (m ³ /s)	Suspended Sediment Concentration (mg/L)	DOC Concentration (mg/L)	POC Concentration (mg/L)
Geneva (DS)	D06-1	11-Jul-06	1.293	0.96	0.53	0.009
La Ronde	D06-5	11-Jul-06	0.187	—*	0.59	—
St. Joseph's	D06-9	12-Jul-06	0.030	3.88	2.72	0.064
Bateli	D06-10	12-Jul-06	0.411	0.38	1.19	0.006
Hampstead	D06-16	13-Jul-06	2.982	46.68	0.48	0.177
Rosalie	D06-4	11-Jul-06	3.411	—	1.17	—
Mahaut	D06-6	11-Jul-06	0.016	—	0.60	—
Dublanc	D06-11	12-Jul-06	0.419	—	0.86	—
Blenheim	D06-15	13-Jul-06	1.601	1.84	0.94	0.007
Layou (DS)	D06-8	12-Jul-06	8.211	4.24	0.78	0.024
Pagua (DS)	D06-20	13-Jul-06	1.480	77.40	2.80	1.130
Spring 2008 (dry season)						
River Name	Sample Number	Date Sampled	Instantaneous Dry Season Discharge (m ³ /s)	Suspended Sediment Concentration (mg/L)	DOC Concentration (mg/L)	POC Concentration (mg/L)
Geneva (DS)	D08-9	15-Mar-08	0.700	0.96	0.691	0.012
La Ronde	D08-11	15-Mar-08	0.073	—	0.716	—
St. Joseph's	D08-3	14-Mar-08	0.000	3.88	2.323	0.068
Bateli	D08-4	14-Mar-08	0.189	0.38	0.654	0.006
Hampstead	D08-15	16-Mar-08	0.013	46.68	0.66	0.177
Rosalie	D08-13	15-Mar-08	1.873	—	0.238	—
Mahaut	D08-12	15-Mar-08	0.003	—	0.383	—
Dublanc	D08-5	14-Mar-08	0.247	—	0.911	—
Blenheim	D08-14	16-Mar-08	0.434	1.84	0.727	0.026
Layou (DS)	D08-2	14-Mar-08	3.700	4.24	0.703	0.024
Pagua (DS)	D08-17	16-Mar-08	0.525	77.40	0.529	1.037

*data not available

Table 4 - Organic carbon yields, phosphate concentrations, and weathering yields from Dominica rivers

River	Watershed Area* (km ²)	Annual POC yield (t km ⁻² yr ⁻¹)	Annual DOC yield (t km ⁻² yr ⁻¹)	DOC/TOC	Wet Season Phosphate, 2006 (ppb)	Dry Season Phosphate, 2008 (ppb)	H ₄ SiO ₄ Yield* (t km ⁻² yr ⁻¹)
Geneva (DS)	21.2	0.0050	0.92	0.99	2.8	— [†]	46.2
La Ronde	3.0	—	0.95	—	<0.1	4.4	13.1
St. Joseph's	3.4	0.0020	0.51	1.00	<0.1	4.5	3.1
Bateli	12.1	0.0050	0.96	0.99	<0.1	2.1	13.1
Hampstead	20.0	0.62	1.52	0.71	—	—	31.2
Rosalie	30.6	—	2.91	—	<0.1	2.9	57.5
Mahaut	0.80	—	0.27	—	<0.1	3.5	7.9
Dublanç	6.5	—	1.52	—	2.4	2.3	35.8
Blenheim	18.1	0.11	1.94	0.95	1.7	4.1	43.3
Layou (DS)	70.2	0.24	2.32	0.91	0.2	3.9	58.4
Pagua (DS)	24.7	1.7	3.67	0.69	3.2	3.3	11.8

*[Goldsmith *et al.*, 2010][†]data not available

Table 5 - Organic carbon yields worldwide

River	Watershed Area (km ²)	POC Yield (t km ⁻² yr ⁻¹)	DOC Yield (t km ⁻² yr ⁻¹)	DOC/TOC
Major Rivers				
North American rivers *	840000 - 1805000	0.27 - 1.0	0.72 - 1.5	—
Niger [†]	1200000	0.55	0.44	0.44
Amazon [§]	7050000	2.83	4.46	0.61
Changjiang (Yangtze) [§]	1800000	6.14	5.69	0.48
Himalayan rivers [§]	907000 - 1165000	1.79 - 5.22	2.22 - 2.93	—
Orinoco River [§]	880000	1.59	4.82	0.75
High Standing Islands				
Sepik, Papua New Guinea [#]	77000	17.1	5.04	0.23
Grey River, New Zealand **	3831	1.6	5.2	0.76
Nivelle River, Bay of Biscay ^{††}	19000	5.3	—	—
Lanyang Hsi watershed, Taiwan ^{§§}	820	23	—	—
Waipaoa River, New Zealand ^{##}	1580	5.41	—	—
Hokitika River, New Zealand **	363	44	2.1	0.05
Puerto Rico forested montane ***	—	—	0.40 - 5.20	—
Volcanic Regions				
Whangaehu River, New Zealand **	1944	2.6	1.6	0.38
Whanganui River, New Zealand **	6785	3.8	2.4	0.39
Waitara River, New Zealand **	1122	2.9	3.2	0.52
*Telang et al. [1991]	[#] Burns et al. [2008]	^{§§} Kao and Liu [1996]		
[†] Martin and Probst [1991]	**Carey et al. [2005b]	^{##} Gomez et al. [2003]		
[§] Ludwig et al. [1996]	^{††} Coynel et al. [2005]	***McDowell and Asbury [1994]		

Table 6 - Carbon isotope analysis of Dominica rivers

River	Sample ID	Weight [mg]	Nitrogen [%]	Carbon [%]	$\delta^{13}\text{C}_{\text{VPDB}} [\text{‰}]^{\S}$	C/N	1/C _{org}
Layou (DS)	DO8-2	9.530	0.05	0.56	-26.73	11.892	1.785
Layou (DS)	DO8-2*	— [†]	0.22	0.59	-26.33	2.682	1.695
St. Joseph's	DO8-3	3.851	0.18	1.74	-25.13	9.778	0.573
St. Joseph's	DO8-3*	—	0.31	1.68	-24.99	5.419	0.595
Dublanc	DO8-5	3.912	0.13	1.44	-27.83	11.088	0.694
La Ronde	DO8-11	4.477	0.12	1.30	-27.96	11.061	0.769
La Ronde	DO8-11	4.447	0.12	1.36	-27.98	10.973	0.736
Mahaut	DO8-12	2.087	0.26	2.64	-27.71	9.967	0.379
Rosalie	DO8-13	2.729	0.19	1.99	-26.54	10.653	0.504
Blenheim	DO8-14	3.840	0.13	1.43	-27.6	11.269	0.699
Pagua (DS)	DO8-17	4.466	0.12	1.34	-27.99	10.944	0.746
Geneva	DO8-9	4.147	0.14	1.24	-24.96	8.628	0.804
Geneva	DO8-9*	—	0.29	1.25	-24.63	4.310	0.800
Geneva	DO8-9	4.658	0.14	1.24	-24.83	8.879	0.804
Geneva	DO6-1	6.560	0.10	0.97	-27.34	10.026	1.034
Rosalie	DO6-4	8.007	0.08	0.75	-27.04	9.283	1.335
La Ronde	DO6-5	7.240	0.07	0.69	-27.96	9.651	1.447
Mahaut	DO6-6	4.437	0.11	1.21	-26.97	10.959	0.825
St. Joseph's	DO6-9*	—	0.29	1.66	-24.88	5.724	0.602
Bateli	DO6-10	3.363	0.15	1.57	-26.62	10.243	0.639
Dublanc	DO6-11	7.607	0.09	0.78	-26.96	8.369	1.283
Blenheim	DO6-15	12.903	0.05	0.39	-26.26	8.220	2.572
Hampstead	DO6-16*	—	0.24	0.38	-26.79	1.583	2.632
Pagua (DS)	DO6-20*	—	0.30	1.46	-27.82	4.867	0.685

*samples processed in later batch

[†]data not available[§]analytical uncertainty is ± 0.07 per mil

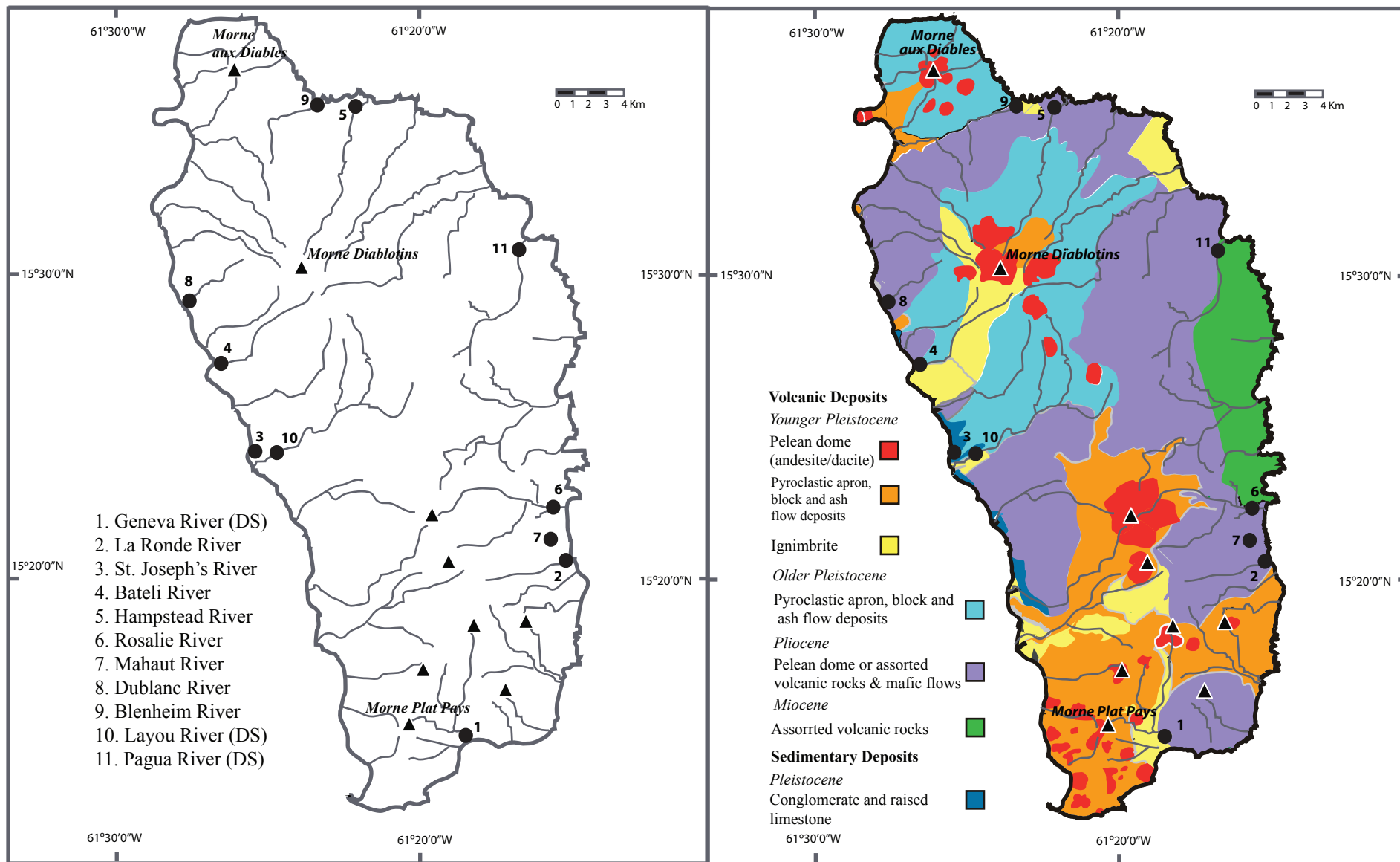


Figure 1 - Sample Locations and Geology of Dominica, Lesser Antilles. The island of Dominica is located in the center of the Lesser Antilles volcanic chain which lies along the eastern edge of the Caribbean plate boundary. Samples were taken near the rivers mouths from eleven rivers around the island. based on Goldsmith et al. [2010] and Roobal and Smith [2004]

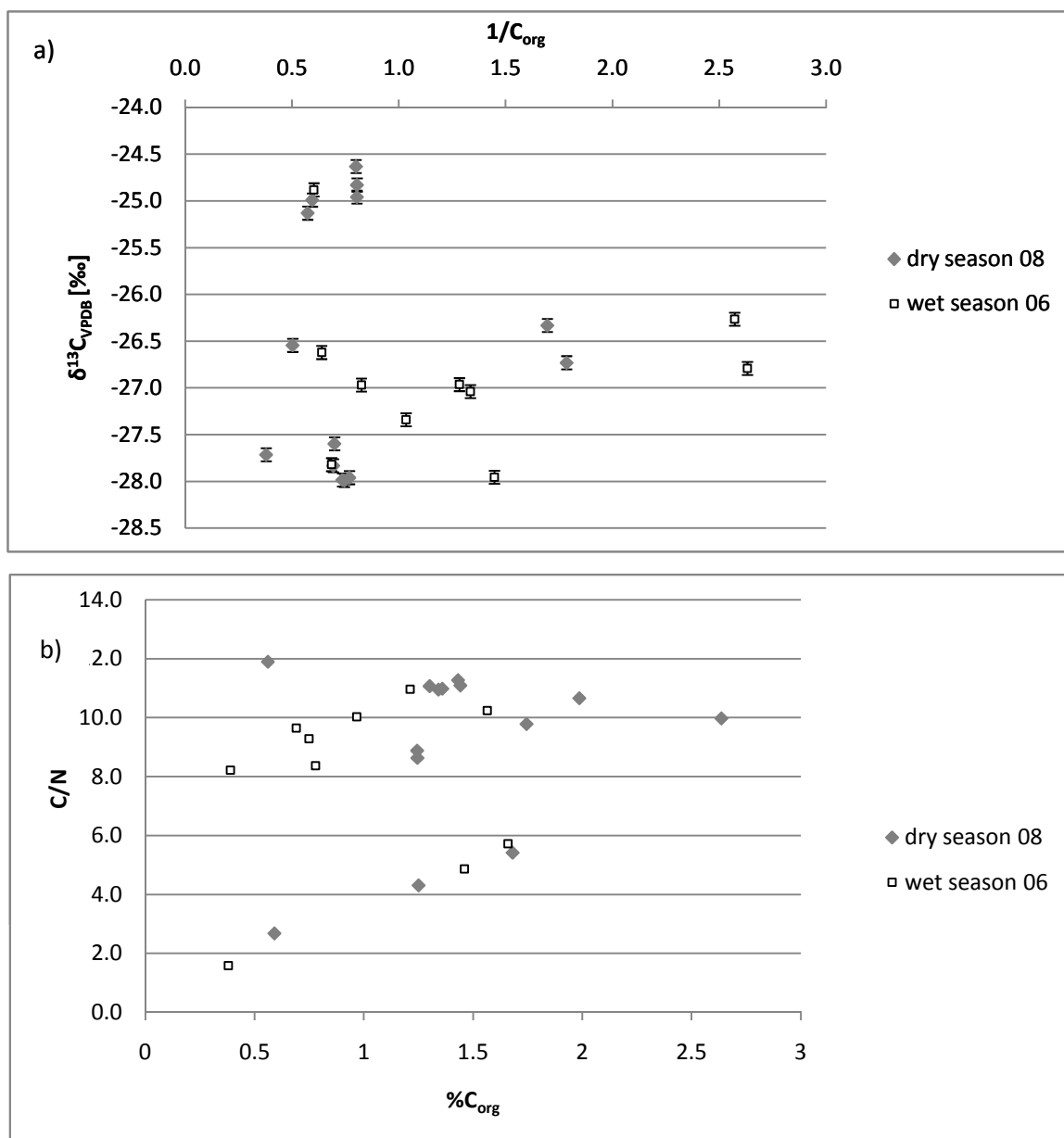


Figure 2 - $\delta^{13}\text{C}$ and C/N comparisons. Analysis of $\delta^{13}\text{C}$ was performed on the sediment samples from the wet and dry seasons of each river. The average $\delta^{13}\text{C}$ value for the wet season samples is -26.86%, whereas the average dry season $\delta^{13}\text{C}$ value is -26.52%. There was no significant difference shown in $\delta^{13}\text{C}$ values between the two seasons and comparison of the $\delta^{13}\text{C}$ and $1/C_{\text{org}}$ showed no trends (a). A comparison of carbon and nitrogen also produced no clear trend (b) among the Dominica rivers.

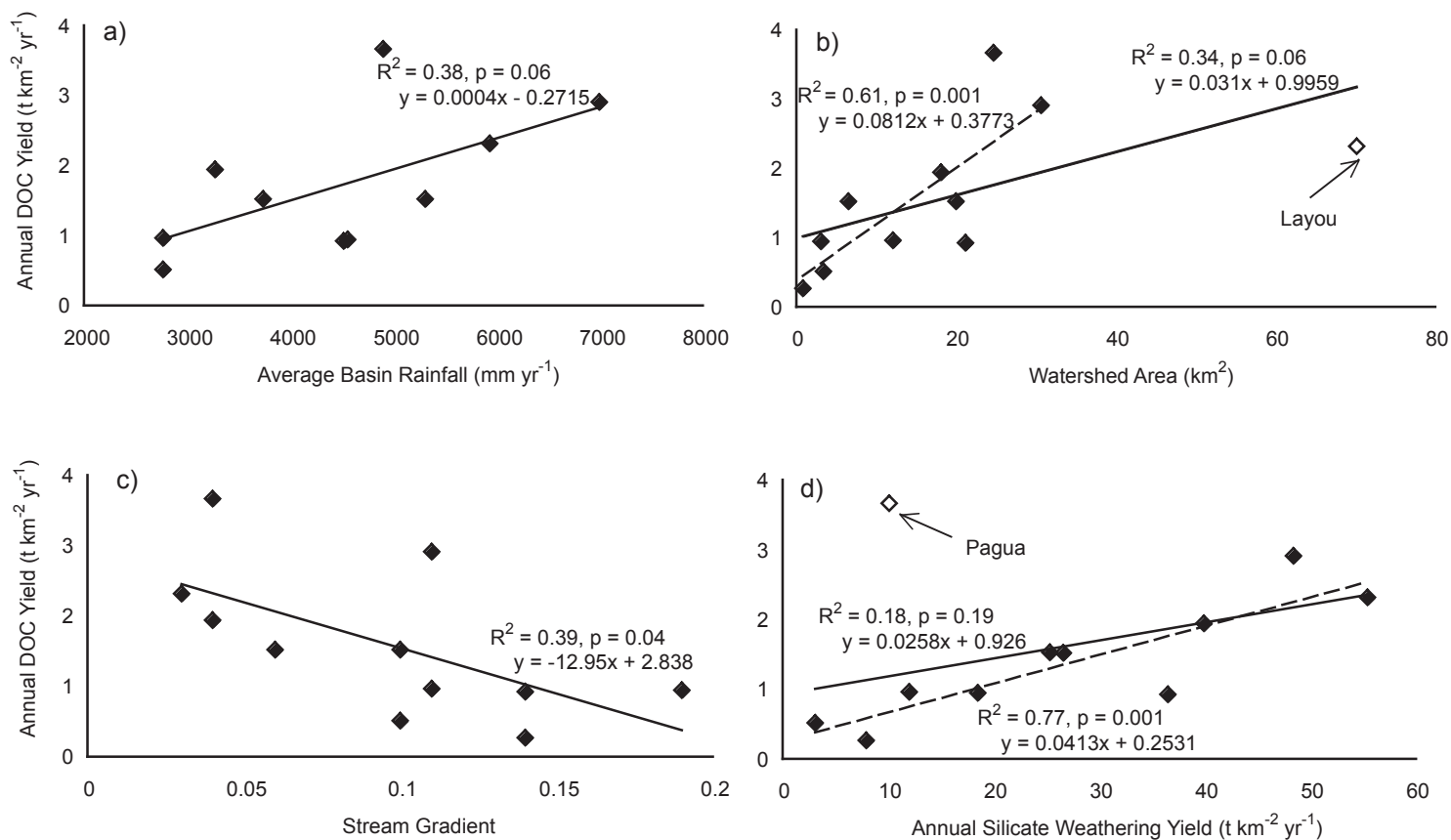


Figure 3 - Controls on DOC in Dominica Rivers. Annual DOC yields plotted versus (a) average basin rainfall, (b) stream gradient, (c) watershed area, and (d) annual silicate weathering yields. DOC yields show a positive correlation with basin rainfall ($R^2 = 0.38$) and stream gradient ($R^2 = 0.39$). A strong correlation ($R^2 = 0.61$) is shown with watershed areas that are less than 40 km^2 . A strong correlation ($R^2 = 0.77$) is also shown with annual silicate weathering yield for watersheds with minimal agricultural influence.